Patent Application of

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for

ARROWHEAD TIP WITH A CUTTING EDGE

This application is a divisional application of my U.S. Patent Application Serial No. 09/ 082 636 filed May 21, 1998 now U.S. Patent 6,306,053 incorporated herein by specific reference, and to which priority is claimed under 35 U.S.C. Section 102.

BACKGROUND - FIELD OF THE INVENTION

This invention relates generally to the forward leading end of arrowheads such as those having faceted cutting tips thereon or cutting tip sections thereof, where the arrowheads have at least one increased sharpness beveled cutting edge.

BACKGROUND - DESCRIPTION OF PRIOR ART

Devices having a leading penetrating end used to penetrate a substance are used in many types of applications, including use in archery equipment and surgical instruments. A popular type of penetrating end point or tip that is used both in archery and surgery is the trocar tip. The word trocar has Latin roots of *tres* meaning three and *carre* meaning side of a sword or knife. A trocar tip is therefore three sided and is the pointed leading end of an object used to cut or pierce. The three sides of trocar tips are generally hollow ground. The term hollow ground refers to the grinding process used to fabricate the sides of the tip and generally means that the sides are dished-out or substantially concave, as compared to being flat. The hollow ground feature gives the tip better defined cutting edges at the juncture of the sides with each other than the cutting edges at side junctures of tips having flat sides. The hollow ground feature also gives the tip the ability to easily push the substance being penetrated away from the tip. The earliest known use of trocar tips date back to the medieval times where they were used on the leading ends of knights' lances.

In surgery a surgical trocar is one type of a surgical instrument that has a leading penetrating end. Surgical trocars are generally used to pierce body cavities during the surgical procedures of dropsy, endoscopy and laparoscopy etc. The penetrating ends of surgical trocars generally have a type of trocar tip, since from such tip they were named. There are various types of surgical trocars, with a variety of different options and accessories available depending on the procedure(s) to be performed. However, the leading end point of the surgical trocar should be as sharp as possible, should push penetrated or cut tissue away from its cutting path, and also should be as cost effective to produce as possible.

In archery a bow is used to shoot an arrow towards a target. A conventional arrow has a

shaft, a nock at one end that receives the bow string, and an arrowhead or point that attaches to the opposite end of the arrow shaft which aids in penetrating the target. Arrowheads generally have a pointed forward end, and an opposite threaded shaft end that attaches the arrowhead to the arrow shaft. Arrowheads come in a variety of different sizes and configurations depending on their intended use. For example, there are specifically designed arrowheads for competitive target shooting, shooting fish, hunting birds or small game animals, and for hunting big game animals.

Arrowheads used for bowhunting are generally know as broadheads. Broadheads have cutting blades and kill game animals by cutting vital organs such as the lungs and vascular vessels such as arteries, which causes rapid hemorrhaging and/or suffocation. Quick and humane kills are dependent on accurate shot placement, and upon the amount or volume of the animal tissue that is cut. Hunting arrowheads that cut more tissue are more lethal, and therefore are better. The volume of tissue that is cut is determined by the cutting diameter of the arrowhead, the number of blades it contains, and by the distance the arrowhead penetrates into the animal. The two most common types of arrowheads used for hunting are fixed-blade arrowheads and blade-opening arrowheads or mechanical arrowheads. Blade-opening arrowheads differ from conventional fixed-blade arrowheads in that the cutting blades are folded up or held adjacent to the arrowhead body in a retracted position while the arrow is in flight, but at impact with the game animal rotate or pivot into an open position, whereas the blades of fixed-blade arrowheads are permanently held at a full cutting diameter position at all times.

Both blade-opening and fixed-blade arrowheads have a pointed tip end used for penetrating the game animal. The tip of the arrowhead may be separably attachable to the arrowhead body or may be integral with it. Conventional arrowheads have historically had two basic types of pointed

arrowhead tips: bone-crushing chisel type tips such as the hollow ground trocar tip, and razor blade type tips. The razor blade tips are generally just an extension of the cutting blades of the arrowhead and terminate in a leading pointed apex. Both types of arrowhead tips are designed to maximize penetration and therefore provide a more lethal arrowhead by cutting a larger volume of animal tissue. Despite their designs and intent both the bone crushing chisel tips and the razor blade tips fall short of providing optimum penetrating performance. Since the arrowhead razor blade type tips generally have a true cutting edge, or a cutting edge that has a small enough angle between opposing sides so as to make it as sharp as a razor or scalpel blade, they penetrate the best through soft tissues such as skin, muscles, lungs and other internal organs by slicing or cutting. But when a razor blade tip impacts bone the thin cutting blade generally gets sheared or broken-off due to the heavy impact forces delivered to it, and thus leaves a blunt snagging leading end that greatly inhibits penetration and therefore is less lethal in many instances - since arrowheads very commonly impact bone when penetrating game animals. The bone-crushing chisel tips on the other hand split right through heavy bone but lack a truly sharp cutting edge and therefore do not perform as well in penetrating the skin and other soft tissues.

Attempts in the prior art have been made to combine a scalpel sharp cutting edge with bone splitting capabilities into an optimally penetrating arrowhead tip, but these attempts have their own problems as well. For example the introduction of chisel tips with hollow ground sides, such as the three sided trocar tip for arrowhead points helped reduce the angle of the cutting edge between the sides of the tip. But the edges of conventional trocar arrowhead tips and other hollow ground arrowhead tips are still relatively dull and are a far cry from having the fine cutting angle or edge a scalpel or razor blade possesses. Other attempts in the prior art to increase the sharpness of the edges

of chisel type arrowhead tips have been made by increasing the curvature of the hollow ground sides. This practice greatly weakens the tip giving it problems similar to those of the razor blade type tips and also provides a tip that does not push the tissue away from the arrowhead optimally.

It is apparent that there are needed improvements in cutting tips.

It is apparent that there is a need for an arrowhead cutting tip that combines the optimal penetration features of the most rugged bone splitting trocar or chisel type arrowhead tips with the razor sharp cutting features of the razor blade type arrowhead tips into one arrowhead tip.

It is also apparent that there is a need for a cutting tip of a surgical trocar that is cost effective to produce, extremely sharp, and that pushes the penetrated or cut tissue away from its cutting path.

SUMMARY OF THE INVENTION

It is one object of the present invention to provide cutting tips and penetrating tips that cut and/or penetrate more efficiently than prior art cutting tips.

It is another object of the present invention to provide a cutting tip that has a smaller angle as referenced between cutting tip structure such as adjoining sides or facets that are located a distance closer to their respective cutting edge than an angle as referenced between cutting tip structure such as adjoining sides or facets located a distance further from the respective cutting edge than the first or closer distance, as measured in the same perpendicular plane to the central longitudinal axis of the respective cutting tip.

It is another object of the present invention to provide a cutting tip that has a side or facet with a cutting edge from which for at least a portion of the time that the cutting edge of the facet is being formed, facet material is removed from only the bisected side of the facet that the cutting edge being formed is on.

It is another object of the present invention to provide a cutting tip that has a side or facet that is formed at least in part from a rotational grinding wheel whose axis of rotation is inclined with respect to the central longitudinal axis of the cutting tip when forming at least a portion of the facet.

It is another object of the present invention to provide a cutting tip that has a side or facet with a facet bisecting plane, wherein the facet is formed at least in part from a rotational grinding wheel whose axis of rotation is inclined with respect to the bisecting plane of the facet when forming at least a portion of the facet.

It is another object of the present invention to provide a cutting tip having a central longitudinal axis that is collinear with the Y-axis of a Cartesian X-Y-Z axis system, and a side or

facet that is formed from a plurality of rotational machining tools -such as grinding wheels- each having an axis of rotation where the axis of rotation of at least one rotational machining tool of the plurality of rotational machining tools is oriented, with respect to at least one of the X-Y-Z axises and therefore at least one of the corresponding three dimensional planes X-Y, X-Z and Y-Z when forming its particular portion of the facet or cutting tip, in a different manner or spatial orientation than the spatial orientation the axis of rotation of at least one other rotational machining tool of the plurality of rotational machining tools when the other rotational machining tool is forming its particular portion of the facet or cutting tip.

It is another object of the present invention to provide a cutting tip that has a side or facet that is formed from a plurality of rotational machining tools each having a radius of rotation where at least one rotational machining tool of the plurality of rotational machining tools has a radius of rotation that has a different length of radius than the radius of rotation of at least one other rotational machining tool.

It is another object of the present invention to provide a cutting tip that has a side or facet that is formed from a plurality of rotational machining tools each having an axial thickness where at least one rotational machining tool of the plurality of rotational machining tools has a different axial thickness than the axial thickness of at least one other rotational machining tool.

It is another object of the present invention to provide a cutting tip that has a side or facet that is formed from a plurality of rotational machining tools each having an exterior circumferential profile where at least one rotational machining tool of the plurality of rotational machining tools has a different exterior circumferential profile than the exterior circumferential profile of at least one other rotational machining tool.

It is also another object of the present invention to provide a cutting tip whose barrel portion has a razor sharp cutting edge.

It is also another object of the present invention to provide a cutting tip which has tip blades.

It is also another object of the present invention to provide a blade-opening arrowhead having blades that pivot in a rearward direction away from the tip of the arrowhead, which has a razor sharp cutting tip to enhance penetration.

It is still another object of the present invention to provide a faceted cutting tip of a surgical trocar that is cost effective to produce, extremely sharp, and that pushes the penetrated or cut tissue away from its cutting path.

It is yet further another object of the present invention to provide an arrowhead cutting tip that combines the optimal penetration features of the most rugged bone splitting trocar or chisel type arrowhead tips with the razor sharp cutting features of the razor blade type arrowhead tips into one arrowhead tip.

The foregoing objects and advantages and other objects and advantages of the present invention are accomplished as according to one preferred embodiment of this invention with a three faceted hollow ground stainless steel cutting tip that has a bevel ground on each facet adjacent to and communicating with each cutting edge which is located at each facet juncture with an adjacent facet, such that the angle between the bevel of one facet and the facet on the side of the cutting edge opposite the facet with the bevel thereon is less than an angle measured between points located a distance from the cutting edge that is beyond the bevel or further from the cutting edge than the bevel. Such a cutting tip is preferably formed by first grinding the three hollow ground facets with a specific grinding wheel, and then by grinding each of the three bevels on the hollow ground facets

with a different grinding wheel. Such a cutting tip enables the formation of an extremely sharp cutting edge at each facet juncture, such as that is attainable on a scalpel blade or a razor blade, while retaining the facet structure necessary to optimally push penetrated material away from the cutting tip and to easily split and crush heavy bone. Such a cutting tip would in effect combine the optimal penetration features of the most rugged bone splitting trocar or chisel type arrowhead tips with the razor sharp cutting features of the razor blade type arrowhead tips into one arrowhead tip, and thus create a deep penetrating and ultimately tough and lethal trocarazor or trocrazor arrowhead tip.

Another preferred embodiment according to this invention differs from the above described embodiment in that there are two bevels formed upon each facet so that each cutting edge has a bevel on either side of it.

Other preferred embodiments according to this invention have razor sharp cutting edges located on the barrel portion of each cutting tip, or the portion of the cutting tip reward of the facets. According to some such embodiments the cutting tips may have both razor sharp edges located upon the barrel section of the tips and also at the facet junctures.

Yet other preferred embodiments according to this invention differ from the above described embodiments in that the razor sharp edges are attained by attachment of separate razor blades or tip blades to the cutting tips by inserting them into slots in the cutting tip body. According to some such preferred embodiments the tip blades are integrally attached to the tip body, such as by welding. According to other such preferred embodiments the attachable tip blades are removably attachable.

Yet still other preferred embodiments according to the cutting tips of this invention differ from the above described embodiments in that the facets are flat or convex, or that the cutting tips

have differing numbers of facets or differing shapes, may be made of different materials, may have friction reducing elements applied thereto such as polytetrafloroethylene (PTFE), and may have different numbers of cutting edges associated therewith.

The cutting tips according to this invention overcome deficiencies inherit in prior art cutting tips. The cutting tips according to this invention have sharper edges while retaining optimal strength and optimal material pushing capabilities. The cutting tips as according to this invention provide for a more lethal arrowhead tip that is capable of deeper penetration than prior art arrowhead tips. The cutting tips according to this invention are also simple and feasible to manufacture.

With the above objects and advantages in view, other objects and advantages of the invention will more readily appear as the nature of the invention is better understood, the invention is comprised in the novel construction, combination and assembly of parts hereinafter more fully described, illustrated, and claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a cutting tip according to one preferred embodiment of this invention;

FIG. **2** is another side view of the cutting tip of FIG. **1**;

FIG. **3** is a top view of the cutting tip of FIG. **1**;

FIG. **4** is a cross-sectional view of the cutting tip of FIG. **1** taken along line **4-4**;

FIG. **5** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **4**;

FIG. **6** is a side view of a fixed-blade arrowhead with a cutting tip according to a preferred embodiment of this invention;

FIG. **7** is a side view of a blade-opening arrowhead with a cutting tip according to a preferred embodiment of this invention, showing the pivotal blades in the closed position;

FIG. **8** is a side view of the blade-opening arrowhead as illustrated in FIG. **7** showing the pivotal blades in the open position;

FIG. **9** is a side view of a blade-opening arrowhead similar to the blade-opening arrowhead as illustrated in FIGS. **7 & 8** except the cutting tip is integral with the arrowhead body.

FIG. **10** is a side view of a surgical trocar with a removably attachable cutting tip as according to a preferred embodiment of this invention;

FIG. **11** is a side view of another surgical trocar with an integral cutting tip as according to a preferred embodiment of this invention;

FIG. **12** is a side view of a three faceted hollow ground cutting tip;

FIG. **13** is a top view of the cutting tip as illustrated in FIG. **12**;

FIG. **14** is a side view of a grinding wheel;

FIG. **15** is an illustration of the three dimensions as depicted with a Cartesian X-Y-Z axis system;

FIG. **16** is a top view of the cutting tip as illustrated in FIG. **13** showing a grinding wheel grinding a bevel on the cutting tip;

FIG. **17** is a side view of the cutting tip and grinding wheel as illustrated in FIG. **16**;

FIG. **18** is a side view of another grinding wheel;

FIG. **19** is a side view of another grinding wheel;

FIG. **20** is a side view of another three faceted hollow ground cutting tip;

FIG. **21** is a top view of the cutting tip as illustrated in FIG. **20**;

FIG. **22** is a side view of another grinding wheel;

FIG. **23** is an illustration of the three dimensions as depicted with a Cartesian X-Y-Z axis system;

FIG. **24** is a top view of the cutting tip as illustrated in FIG. **21** showing a grinding wheel grinding a bevel on the cutting tip;

FIG. **25** is a side view of the cutting tip and grinding wheel as illustrated in FIG. **24**;

FIG. **26** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **27** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **26**;

FIG. **28** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **29** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **28**;

FIG. **30** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **31** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **30**;

FIG. **32** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **33** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **32**;

FIG. **34** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **35** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **34**;

FIG. **36** is a side view of another cutting tip as according to this invention;

FIG. **37** is another side view of the cutting tip as illustrated in FIG. **36**;

FIG. **38** is a top view of the cutting tip as illustrated in FIG. **36**;

FIG. **39** is a cross-sectional view of the cutting tip as illustrated in FIG. **36** taken along line **39-39**;

FIG. **40** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **39**;

FIG. **41** is a side view of another cutting tip as according to this invention;

FIG. **42** is another side view of the cutting tip as illustrated in FIG. **41**;

FIG. **43** is a top view of the cutting tip as illustrated in FIG. **41**;

FIG. **44** is a cross-sectional view of the cutting tip as illustrated in FIG. **41** taken along line **44-44**;

FIG. **45** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **44**;

FIG. **46** is a side view of a fixed-blade arrowhead with a cutting tip according to a preferred embodiment of this invention;

FIG. **47** is a side view of a blade-opening arrowhead with an integral cutting tip according to a preferred embodiment of this invention, showing the pivotal blades in the open position;

FIG. **48** is a side view of a surgical trocar with a removably attachable cutting tip as according to a preferred embodiment of this invention;

FIG. **49** is a side view of another surgical trocar with an integral cutting tip as according to a preferred embodiment of this invention;

FIG. **50** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **51** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **50**;

FIG. **52** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **53** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **51**;

FIG. **54** is a side view of another cutting tip as according to a preferred embodiment of this invention showing a hone bevel;

FIG. **55** is a cross-sectional view of the cutting tip as illustrated in FIG. **54** taken along line **55-55**;

FIG. **56** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **55**;

FIG. **57** is an enlarged view of a cutting edge from the cross-sectional view of another cutting tip as according to this invention showing another hone bevel;

FIG. **58** is an enlarged view of a cutting edge from the cross-sectional view of another cutting tip as according to this invention showing another hone bevel;

FIG. **59** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **60** is an enlarged view of a cutting edge from the cross-sectional view of FIG. **59**;

FIG. **61** is a side view of another cutting tip as according to this invention;

FIG. **62** is another side view of the cutting tip as illustrated in FIG. **61**;

FIG. **63** is a top view of the cutting tip as illustrated in FIG. **61**;

FIG. **64** is a cross-sectional view of the cutting tip as illustrated in FIG. **61** taken along line **64-64**;

FIG. **65** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **66** is a side view of another cutting tip as according to this invention;

FIG. **67** is a cross-sectional view of the cutting tip as illustrated in FIG. **66** taken along line **67-67**;

FIG. **68** is an exploded side view of the cutting tip as according to the preferred embodiment of this invention as illustrated in FIG. **66** showing the cutting tip with the tip blades removed;

FIG. **69** is a side view of another cutting tip as according to this invention;

FIG. **70** is a top view of the cutting tip as illustrated in FIG. **69**;

FIG. **71** is a cross-sectional view of the cutting tip as illustrated in FIG. **69** taken along line **71-71**;

FIG. **72** is a cross-sectional view of the cutting tip as illustrated in FIG. **69** taken along line **72-72**;

FIG. **73** is a side view of another cutting tip as according to this invention;

FIG. **74** is a cross-sectional view of the cutting tip as illustrated in FIG. **73** taken along line **74-74**;

FIG. **75** is a cross-sectional view of the cutting tip as illustrated in FIG. **73** taken along line **75-75**;

FIG. **76** is an exploded side view of the cutting tip as according to the preferred embodiment of this invention as illustrated in FIG. **73** showing the cutting tip with the tip blades removed;

FIG. **77** is a side view of another cutting tip as according to this invention;

FIG. **78** is a top view of the cutting tip as illustrated in FIG. **77**;

FIG. **79** is a top view of another cutting tip as according to this invention;

FIG. **80** is a top view of another cutting tip as according to this invention;

FIG. **81** is a top view of another cutting tip as according to this invention;

FIG. **82** is a side view of another cutting tip as according to this invention;

FIG. **83** is a top view of the cutting tip as illustrated in FIG. **82**;

FIG. **84** is an exploded side view of the cutting tip as illustrated in FIG. **82** showing two tip blades detached from the cutting tip;

FIG. **85** is a side view of a blade-opening arrowhead with a cutting tip as according to a preferred embodiment of this invention, showing the pivotal blades in the open position;

FIG. **86** is a side view of another blade-opening arrowhead similar to the blade-opening arrowhead as illustrated in FIG. **85** except for the cutting tip is integral with the arrowhead body.

FIG. **87** is a cross-sectional view of the cutting tip as illustrated in FIG. **86** taken along line **87-87**;

FIG. **88** is a cross-sectional view of another cutting tip as according to this invention;

FIG. **89** is an exploded side view of an arrowhead body and cutting tip as according to this invention;

FIG. **90** is a partially sectioned side view of the assembled arrowhead components as illustrated in FIG. **89**;

FIG. **91** is a side view of another tip blade as according to a preferred embodiment to this invention;

FIG. **92** is an exploded side view of an arrowhead body and cutting tip as according to this invention;

FIG. **93** is a partially sectioned side view of the assembled arrowhead components as illustrated in FIG. **92**;

FIG. **94** is a side view of an arrowhead body and cutting tip as according to this invention;

FIG. **95** is a partially sectioned side view of the assembled arrowhead components as illustrated in FIG. **94**;

FIG. **96** is a perspective view of the tip blade as illustrated in FIGS. **94 & 95**;

FIGS. **97a-c** show other tip blades as according to other preferred embodiments of this invention;

FIG. **98** is a side view of an arrowhead body and cutting tip as according to this invention;

FIG. **99** is a partially sectioned side view of the assembled arrowhead components as illustrated in FIG. **98**;

FIG. **100** is a side view of an arrowhead body and cutting tip as according to this invention;

FIG. **101** is a partially sectioned side view of the assembled arrowhead components as illustrated in FIG. **100**;

FIG. **102** shows another tip blade as according to another preferred embodiment of this invention;

FIG. **103** is a side view of a fixed-blade arrowhead with a cutting tip as according to a preferred embodiment of this invention;

FIG. **104** is a top view of the fixed-blade arrowhead as illustrated in FIG. **103**;

FIG. **105** is an exploded side view of the arrowhead body and cutting tip of the arrowhead as

illustrated in FIG. **103**;

FIG. **106** is a partially sectioned side view of the assembled arrowhead components as illustrated in FIG. **105**;

FIG. **107** is a side view of another fixed-blade arrowhead blade according to another preferred embodiment of this invention;

FIG. **108** is a top view of another fixed-blade arrowhead having a cutting tip as according to another preferred embodiment of this invention;

FIG. **109** is a partially sectioned side view of the arrowhead body and cutting tip as according to the preferred embodiment of this invention as illustrated in FIG. **108**;

FIG. **110** is a side view of a tip blade of the cutting tip of the fixed-blade arrowhead of this invention as illustrated in FIGS. **108 & 109**;

FIG. **111** is an exploded side view of another cutting tip as according to this invention;

FIG. **112** is a side view of another cutting tip as according to this invention;

FIG. **113** is a cross-sectional view of the cutting tip as illustrated in FIG. **112** taken along line **113-113**;

FIG. **114** is a top view of another cutting tip as according to this invention;

FIG. **115** is a side view of the cutting tip of this invention as illustrated in FIG. **114**;

FIG. **116** is a top view of another cutting tip as according to this invention;

FIG. **117** is a side view of the cutting tip of this invention as illustrated in FIG. **116**; and

FIGS. **118-131** are cross-sectional views of yet other cutting tips as according to this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1-5** illustrate a preferred embodiment of this invention, wherein a cutting tip **200** has three hollow ground facets **400-400-400**. Each facet **400** is ground upon a barrel section **900** of cutting tip **200**. Cutting tip **200** tapers to a pointed apex **376** at its forward leading end as illustrated in FIG. **1**. Each facet **400** has a bevel **500** ground thereon. Bevels **500-500-500** create a sharper cutting edge **300** at the facet junctures of cutting tip **200** than is attainable by a conventional trocar tip having only hollow ground facets, while allowing cutting tip **200** to retain sufficient structural facet strength to crush/split heavy bone and easily push penetrated material from its cutting path. Each facet **400** has a pair of facet boundaries. Each facet boundary is defined by a cutting edge **300** where a facet **400** adjoins an adjacent facet **400**. A facet **400** and other facets of the other preferred cutting tip embodiments of this invention is therefore generally defined as the cutting tip structure between the pair of facet boundaries or cutting edges of the respective facet. Therefore each bevel is part of its accompanying facet. Each bevel **500** creates a bevel boundary **600** upon its corresponding facet **400**. Each bevel boundary **600** marks the location on each facet **400** where the slope of the corresponding facet **400** changes, as is readily determined by observation of a cross-sectional view of cutting tip **200** such as is illustrated in FIG. **4**. The cross-sectional views of cutting tip **200** as shown in FIGS. **4 & 5** are taken in a plane perpendicular to a central longitudinal axis **1010** of cutting tip **200**. Central longitudinal axis **1010** is collinear with the Y-axis of a Cartesian X-Y-Z axis system as illustrated in FIGS **1 & 4**. A facet bisecting plane **660** as also illustrated in FIGS. **1 & 4** bisects each facet **400** into two longitudinal halves. Each bevel **500** of cutting tip **200** is substantially on only one bisected side of its corresponding facet **400**. As illustrated in FIG. **1** bevel **500** is on the right side of corresponding bisecting plane **660**. As also illustrated in FIG. **1**

facet bisecting plane **660** is coplanar with the Y-Z plane (coming out of the page).

As illustrated in FIG. **5** an enlarged cross-sectional view of one of the cutting edges **300** of cutting tip **200** clearly shows that a proximal angle **670** has an angle of measure that is less than the angle of measure of a distal angle **672** which therefore gives each cutting edge **300** of cutting tip **200** a true cutting edge and therefore its razor or scalpel sharpness, while retaining the optimally desired facet structure. A true cutting edge is a cutting edge that has a small enough angle between opposing structure such as facets or sides so as to make it as sharp as a razor blade or scalpel blade. It is within the desired results of this invention to provide cutting tips, such as three faceted hollow ground trocar tips that have such a true cutting edge located at each facet juncture. However, it is apparent that obtaining such a fine or small angle so as to produce a true cutting edge between opposing facets or other structures of the cutting tips as according to this invention is not of necessity a requirement for all cutting tips as according to this invention, but rather the creation of a finer or sharper edge than prior art cutting tips possess at their facet junctures and/or at their other structural sections. Proximal angle **670** has preferably an angular measure of between 10 and 35 degrees, but is not intended to be limited thereto. Proximal angle **670** is determined by measuring the angle in a plane perpendicular to central longitudinal axis **1010** of cutting tip **200** between a pair of proximal angle measuring reference points **1000 & 1002** and cutting edge **300**. Distal angle **672** is determined by measuring the angle in the same perpendicular plane to central longitudinal axis **1010** of cutting tip **200** between a pair of distal angle measuring reference points **1004 & 1006** and cutting edge **300**.

It is apparent that the method of determining the angle that adjoining facets, bevels or their equivalents are offset from each other with respect to the shape of their corresponding cutting tips and cutting edges as according to this invention may not have to be referenced from the

corresponding cutting edge it self.

Proximal angle **670** and other proximal angles or their equivalents as according to the desired results of this invention which create an angle of measure that is less than distal angle **672** or other similar corresponding distal angles or their equivalents as according to this invention may be any angle that has angle measuring reference points located a distance from their corresponding cutting edge less than the distance their corresponding bevel boundary is from the cutting edge, as referenced in a plane perpendicular to the central longitudinal axis of the respective cutting tip. Distal angle **672** and other distal angles or their equivalents as according to the desired results of this invention which create an angle of measure that is greater than proximal angle **670** or other similar proximal angles or their equivalents as according to this invention therefore may be any angle that has angle measuring reference points located a distance from their corresponding cutting edge not less than the distance their corresponding bevel boundary is from the cutting edge, as referenced in a plane perpendicular to the central longitudinal axis of the respective cutting tip.

It is apparent that each point of a pair of angle measuring reference points used to determine the angle of measure, and therefore the angular offset of opposing cutting tip structural sections, whether a proximal angle or a distal angle as according to this invention, need not necessarily be the same distance from their corresponding cutting edge.

FIGS. **6-11** illustrate examples of types of devices that have a leading penetrating end used for penetrating substances which cutting tip **200** or other cutting tips as according to this invention can be associated with as according to the scope of this invention. FIG. **6** illustrates a fixed-blade arrowhead **702** that has cutting blades **722-722-722** and cutting tip **200** removably attached to an arrowhead body **732**. FIGS. **7 & 8** illustrate a blade-opening arrowhead **700** that has pivotal cutting

blades **720-720-720** and cutting tip **200** removably attached to an arrowhead body **730**. FIG. **7** shows pivotal blades **720-720-720** in the closed or in-flight position, whereas FIG. **8** shows pivotal blades **720-720-720** in the open cutting position. FIG. **9** shows a blade-opening arrowhead **704** similar to blade-opening arrowhead **700** as illustrated in FIGS. **7 & 8** except for a cutting tip **204** is integrally attached with an arrowhead body **731**. FIG. **10** illustrates a surgical trocar **706** that has a cannula **740** or trocar tube, a mandrel shank **744** or trocar obturator shank with cutting tip **200** removably attached thereto. FIG. **11** illustrates another surgical trocar **708** similar to surgical trocar **706** except for a cutting tip **202** is integrally attached with a mandrel shank **742**.

The cutting tips according to this invention are preferably fabricated from metal stock material such as 400 series stainless steels, titanium alloys - including beta alloys, ferrous steels and carbides, but may be fabricated in their entirety or in part from other metals and non-metals such as organic polymers, composites or any combination of such materials or any other plausible materials.

It is apparent that friction reducing elements such as polytetrafloroethylene (PTFE) may be applied to the cutting tips of this invention, especially to the cutting tips fabricated of metal, to enhance their penetrating qualities.

FIGS. **12-17** illustrate in part a method of manufacturing cutting tip **200**. FIG. **12** shows a conventional three faceted hollow ground trocar tip, that had its facets **400-400-400** ground by a grinding wheel **800** as illustrated in FIG. **14**. Grinding wheel **800** has a radius of rotation **804**, an axial thickness **802** and an exterior circumferential profile **836**. Grinding wheel **800** is a type of rotational machining tool as according to this invention, because it rotates about an axis or spins and when shaping or forming objects. Other rotational machining tools as according to this invention comprise mill cutter heads, sanding wheels and any other type of shape forming device that rotates

around at least one axis. In FIG. **14** radius of rotation **804** is depicted as the greatest radius of grinding wheel **800**, but it is apparent that the radius of rotation **804** of grinding wheel **800** and the radiuses of rotation of other grinding wheels and rotational machiniog tools as according to this invention may be any actual radial length possessed by the rotational machining tool or grinding wheel, since such grinding wheels and/or rotational machining tools may have changing radial lengths throughout their axial thickness as does grinding wheel **800**. The exterior circumferential profile of a rotational machining tool of this invention refers to surface shape of the part of the rotational machining tool that is actually contacting the object being formed, manufactured or ground. Although grinding wheel **800** forms each hollow ground facet **400** of cutting tip **200** by exterior circumferential profile **836** section of grinding wheel **800** removing cutting tip stock material during the grinding process, it is apparent that a section **837** of grinding wheel **800** could be used to grind or fabricate a facet, particularly a flat facet, of a cutting tip as according to this invention wherein section **837** would be an exterior circumferential profile.

FIG. **13** illustrates that the axis of rotation **1008** of grinding wheel **800**, when grinding wheel **800** is grinding a facet **400** upon cutting tip **200**, is substantially parallel to central longitudinal axis **1010** or the Y-axis, and is perpendicular to both the X-axis and Z-axis. Axis of rotation **1008** of grinding wheel **800**, when grinding wheel **800** is grinding each facet **400** upon cutting tip **200**, is therefore not inclined relative to any of the X, Y, or Z axises nor any of the three dimensions - their corresponding two dimensional planes; X-Z, X-Y, Y-Z. The term inclined as according to this invention has the intended meaning of being neither perpendicular nor parallel.

Axis of rotation **1008** of grinding wheel **800** when grinding wheel **800** is grinding each facet **400** upon cutting tip **200**, is orientated with respect to the X-Y-Z axis system of cutting tip 200 in

a specific spatial orientation. A spatial orientation as according to this invention refers to the three-dimensional occupancy of space, and particularly to the three-dimensional occupancy of space that axises of rotation of grinding wheels and/or rotational machining tools are oriented with respect to a corresponding Cartesian X-Y-Z axis system of a corresponding cutting tip.

FIGS. **16 & 17** show another grinding wheel **806** grinding a bevel **500** upon one of the facets **400** after grinding wheel **800** formed facets **400-400-400**. Grinding wheel **806** has a radius of rotation **810**, an axial thickness **808** and an exterior circumferential profile **838**. The radius of rotation **810** of grinding wheel **806** is of a different length of radius than the radius of rotation **804** of grinding wheel **800**. The axial thickness **808** of grinding wheel **806** is of a different thickness than the axial thickness **802** of grinding wheel **800**. The exterior circumferential profile **838** of grinding wheel **806** is also of a different profile than the exterior circumferential profile **836** of grinding wheel **800**.

As is illustrated in FIGS. **16 & 17** the axis of rotation **1012** of grinding wheel **806** is inclined relative to each of the X, Y, and Z axises of a Cartesian X-Y-Z axis system and therefore also inclined to the corresponding X-Y, X-Z, and Y-Z planes when grinding wheel **806** is forming each bevel **500** upon cutting tip **200**. Therefore, the axis of rotation **1012** of grinding wheel **806** when forming a bevel **500** upon a particular facet **400** of cutting tip **200** is oriented with respect to at least one of the X-Y-Z axises and corresponding three dimensional planes in a different relation or spatial orientation than the spatial orientation axis of rotation **1008** of grinding wheel **800** is oriented with respect to the X-Y-Z axises and three dimensional planes when forming the particular portion of the facet - the primary structure or the hollow ground facets. Each bevel **500** is substantially on only one bisected side of its corresponding facet **400**, thus grinding wheel **806** when forming a bevel **500** upon

a facet **400** is removing facet material or cutting tip stock material from only one bisected side of that facet **400** for a substantial majority of the time that grinding wheel **806** is forming the particular bevel **500**. This is clearly illustrated in FIG. **16** where the bevel **500** grinding wheel **806** is shown forming is substantially completely on the right side of facet bisecting plane **660**, which bisecting plane **660** happens to be aligned coplanar with the Y-Z plane (coming out of the page) as seen in FIG. **16**. Removing facet material or cutting tip stock material with a grinding wheel or other rotational machining tool when forming a portion of a facet such as when grinding wheel **806** is forming a bevel **500**, is in essence cutting or making a cut from the cutting tip stock material when fabricating it as according to this invention.

FIG. **18** shows a grinding wheel **812** which has a radius of rotation **816**, an axial thickness **814** and an exterior circumferential profile **840**. FIG. **19** shows a grinding wheel **818** which has a radius of rotation **822**, an axial thickness **820** and an exterior circumferential profile **842**. Both grinding wheels **812** and **818** could be used to grind bevels similar to bevels **500-500-500** upon facets **400-400-400** of cutting tip **200**, however due to their different exterior circumferential profiles and potentially different axial thicknesses, potentially different radii of rotation and the different possible relations their axises of rotation can be oriented with respect to the three dimensions of the X-Y-Z axises of corresponding cutting tips, the bevels grinding wheels **812** and **818** would grind could have a variety of different shapes, slopes and/or curvatures than that of bevels **500-500-500** as shown on cutting tip **200**.

FIGS. **20-25** illustrate in part another method of manufacturing a cutting tip **206** that is similar to cutting tip **200** and similar to the method as disclosed in FIGS. **12-17** except the method of manufacturing cutting tip **206** as illustrated in FIGS. **20-25** first entails grinding the hollow ground

trocar tip facets **402-402-402** by a grinding wheel **824** as illustrated in FIG. **22** wherein the axis of rotation **1014** of grinding wheel **824** is oriented substantially perpendicular to central longitudinal axis **1018** of cutting tip **206** when grinding each facet **402** thereon. Grinding wheel **824** has a radius of rotation **828**, an axial thickness **826**, and an exterior circumferential profile **844**. Axis of rotation **1014** of grinding wheel **824** is oriented in a specific spatial orientation when grinding a hollow ground facet **402** on cutting tip **206**, particularly axis of rotation **1014** is spatially oriented substantially perpendicular to both a central longitudinal axis **1018** or the Y-axis and to the Z-axis, while being substantially parallel to the X-axis. Axis of rotation **1014** of grinding wheel **824**, when grinding wheel **824** is grinding each facet **402** upon cutting tip **206**, is therefore not inclined relative to any of the X-Y-Z axises nor any of the three dimensions. FIGS. **24** & **25** show that another grinding wheel **830** next grinds a bevel **502** upon each of the facets **402** after grinding wheel **824** formed facets **402-402-402**. Bevels **502-502-502** create a sharper cutting edge **302** at the facet junctures of cutting tip **206** than is attainable by a conventional trocar tip having only hollow ground facets as shown for example in FIGS. **20** & **21**, while allowing cutting tip **206** to retain sufficient structural facet strength to crush/split heavy bone and easily push penetrated material from its cutting path. Each bevel **502** creates a bevel boundary **602** upon its corresponding facet **402**. Grinding wheel **830** has a radius of rotation **834**, an axial thickness **832** and an exterior circumferential profile **846**. The radius of rotation **834** of grinding wheel **830** is of a different length of radius than the radius of rotation **828** of grinding wheel **824**. The axial thickness **832** of grinding wheel **830** is of a different thickness than the axial thickness **826** of grinding wheel **824**. The exterior circumferential profile **846** of grinding wheel **830** is also of a different profile than the exterior circumferential profile **844** of grinding wheel **824**.

As is illustrated in FIGS. **24 & 25** axis of rotation **1016** of grinding wheel **830** is inclined relative to each of the X, and Z axises in a specific spatial orientation and therefore to two of the corresponding three dimensional planes -the X-Y, and Y-Z planes- when grinding wheel **830** is forming each bevel **502** thereon. However, axis of rotation **1016** of grinding wheel **830** is perpendicular to the Y-axis or central longitudinal axis **1018** of cutting tip **206** and is parallel to the X-Z plane when grinding wheel **830** is forming each bevel **502**. Therefore, the axis of rotation **1016** of grinding wheel **830** when forming a bevel **502** upon a particular facet **402** of cutting tip **206** is oriented with respect to at least one of the X-Y-Z axises and corresponding three dimensional planes in a different relation or spatial orientation than the spatial orientation axis of rotation **1014** of grinding wheel **824** is oriented with respect to the X-Y-Z axises and three dimensional planes when forming the particular facet. Each bevel **502** is substantially on only one bisected side of its corresponding facet **402**, thus grinding wheel **830** when forming a bevel **502** upon a facet **402** is removing facet material or cutting tip stock material from only one bisected side of facet **402** for a substantial majority of the time that grinding wheel **830** is forming the particular bevel **502**. This is clearly illustrated in FIG. **24** where the bevel **502** grinding wheel **830** is shown forming is substantially completely on the right side of facet bisecting plane **660**, which bisecting plane **660** happens to be aligned coplanar with the Y-Z plane (coming out of the page) as seen in FIG. **24**.

It is apparent that the facets of the cutting tips as according to this invention whether concave/hollow ground or of some other shape may have each primary facet structure such as hollow ground facets **402-402-402** of the conventional trocar tip as illustrated in FIGS. **20 & 21**, formed by rotational machining tools and/or grinding wheels where the axis of rotation of the rotational machining tool or grinding wheel forming such primary facet structure is substantially inclined

relative to one or more of the Cartesian X-Y-Z axises and their corresponding three dimensional planes as has been disclosed in this specification, when forming the corresponding portion of each facet. The term primary facet structure refers generally but not limited thereto, to the facet before a bevel or bevels as according to this invention are formed or ground thereon so as to create a razor sharp cutting edge as is according to the desired results of this invention. Such cutting tips having the primary facet structures or at least a part of a facet formed by a grinding wheel or rotational machining tool whose axis of rotation is inclined with respect to at least one or more of the X-Y-Z axises would then have a bevel or bevels as according to this invention formed on each facet by a grinding wheel or rotational machining tool which would have possibly a different radius of rotation, a different axial thickness, or a different exterior circumferential profile than the grinding wheel or rotational machining tool that formed the primary facet structure. Also, the grinding wheel or rotational machining tool forming the bevel or bevels on the primary facet structure could possibly have its axis of rotation when forming the bevel(s) on a facet of a respective cutting tip, oriented with respect to the X-Y-Z axises in a different manner or relation than the inclined manner or relation the grinding wheel or rotational machining tool that formed the primary facet structure of that facet was oriented with respect to the X-Y-Z axises when forming the primary facet structure as according to this invention. Such different manner or relation of orientation of the axis of rotation of the rotational machining tool or grinding wheel when forming the bevel(s) with respect to the X-Y-Z axises could be either inclined or non-inclined relative to one or more of the X-Y-Z axises and the corresponding three dimensional planes.

FIGS. **26-35** illustrate other preferred cutting tip embodiments as according to the cutting tips of this invention that have at least a part of their facets substantially concave - which may have

been formed from hollow grinding and/or other fabrication methods. FIGS. **26 & 27** show cross-sectional views of a three sided cutting tip **208** having facets **404-404-404**, cutting edges **304-304-304**, bevels **504-504-504**, and bevel boundaries **604-604-604**. FIGS. **28 & 29** show cross-sectional views of a three sided cutting tip **210** having facets **406-406-406**, cutting edges **306-306-306**, bevels **506-506-506**, and bevel boundaries **606-606-606**. FIGS. **30 & 31** show cross-sectional views of a three sided cutting tip **212** having facets **408-408-408**, cutting edges **308-308-308**, bevels **508-508-508**, and bevel boundaries **608-608-608**. FIGS. **32 & 33** show cross-sectional views of a three sided cutting tip **214** having facets **410-410-410**, cutting edges **310-310-310**, bevels **510-510-510**, and bevel boundaries **610-610-610**. FIGS. **34 & 35** show cross-sectional views of a three sided cutting tip **216** having facets **412-412-412**, cutting edges **312-312-312**, bevels **512-512-512**, and bevel boundaries **612-612-612**.

As is apparent from cutting tips **210 & 212** as illustrated in FIGS. **28-31** regardless of how small the distal angle is or how dished-out the concave facets are, a finer or narrower proximal angle is attainable at the cutting edge or juncture of adjoining facets by forming a bevel thereon as according to this invention, and therefore provides a sharper cutting edge than would of been attainable had the bevel or bevels not been formed.

FIGS. **36-40** illustrate a cutting tip **218**. Cutting tip **218** has facets **414-414-414**, cutting edges **314-314-314**, bevels **514-514-514**, and bevel boundaries **614-614-614**. Cutting tip **218** is similar to the cutting tips described above except that the facets **414-414-414** of cutting tip **218** are substantially flat as is best seen in FIG. 39. FIG. **40** shows that a proximal angle **674** has an angle of measure that is less than the angle of measure of a distal angle **676** as according to the proximal and distal angles of this invention and therefore gives cutting tip **218** sharper cutting edges **314-314-**

314 than it would of had if the bevels **514-514-514** had not been formed thereon. It is apparent that other proximal angles having an angle of measure that is greater than the angle of measure of proximal angle **674** are measurable by reference from other locations along bevel **514** of cutting tip **218**. Such other proximal angles would still have an angle of measure that is less than the angle of measure of distal angle **676** as is according to this invention.

It is apparent that the shape or structure of the facets according to the cutting tips of this invention may be concave, flat, convex or have other complex geometries as according to the scope of this invention.

FIGS. **41-45** illustrate a cutting tip **220**. Cutting tip **220** has facets **416-416-416**, cutting edges **316-316-316**, bevels **516-516-516-516-516-516**, and bevel boundaries **616-616-616-616-616-616**. Cutting tip **220** has two bevels **516-516** formed upon each facet **416**. It is apparent that more than one bevel may be formed upon each facet of the cutting tips as according to this invention. FIG. **45** shows that a proximal angle **678** has an angle of measure that is less than the angle of measure of a distal angle **680** as according to the proximal and distal angles of this invention and therefore gives cutting tip **220** sharper cutting edges **316-316-316** than it would of had if the bevels had not been formed thereon.

FIGS. **46-49** illustrate other arrowheads and surgical trocars having cutting tips as according to this invention at their leading penetrating ends. FIG. **46** illustrates a fixed-blade arrowhead **752** that has cutting blades **722-722-722** and cutting tip **220** removably attached to arrowhead body **732**. FIG. **47** illustrates a blade-opening arrowhead **750** that has pivotal cutting blades **720-720-720** and cutting tip **222** integrally attached to or with arrowhead body **731**. FIG. **48** illustrates a surgical trocar **754** that has a cannula **740** or trocar tube, a mandrel shank **744** or trocar obturator shank with

cutting tip **220** removably attached thereto. FIG. **49** illustrates another surgical trocar **756** similar to surgical trocar **754** except for a cutting tip **224** is integrally attached with a mandrel shank **742**.

FIGS. **50-53** illustrate other examples of cutting tips as according to this invention that have two bevels upon each facet such that one bevel of each adjoining facet communicates with each cutting edge. FIGS. **50-51** illustrate a cutting tip **226**. Cutting tip **226** has flat facets **418-418-418**, cutting edges **318-318-318**, bevels **518-518-518-518-518-518**, and bevel boundaries **618-618-618-618-618-618**. FIGS. **52-53** illustrate a cutting tip **228**. Cutting tip **228** also has flat facets **420-420-420**, cutting edges **320-320-320**, bevels **520-520-520-520-520-520**, and bevel boundaries **620-620-620-620-620-620**.

It is apparent that cutting tips as according to this invention could have facets that have only one bevel formed thereon while having other facets that have a plurality of bevels formed thereon.

FIGS. **54-56** illustrate a cutting tip **230**. Cutting tip **230** has hollow ground facets **422-422-422**, cutting edges **322-322-322**, bevels **526-526-526**, hone bevels **528-528-528**, and bevel boundaries **622-622-622**. Hone bevels **528-528-528** serve to provide cutting tip **230** and other cutting tips as according to this invention that have hone bevels or their equivalents with a slightly stronger cutting edge as is commonly done with razor blades, scalpels and other cutting knife type blades, which are generally fabricated from the process of strip grinding. As illustrated in FIG. **56** a proximal angle **690** has an angle of measure that is less than a distal angle **692** as according to this invention. The dotted lines **1032 & 1036** of angle **692** do not intersect each other at cutting edge **322** nor do the dotted lines **1036 & 1034** of angle **690** intersect each other at cutting edge **322**. This is an example as according to this invention of how the method of determining the angle or angles that adjoining facets, bevels, other cutting tip structures or their equivalents are offset from each other

with respect to the shape of their corresponding cutting tips and cutting edges as according to this invention, may not involve referencing from the corresponding cutting edge, but which still determine true angular offsets of such structures.

It is apparent that a proximal angle of less degrees in measure than a distal angle as according to this invention is attainable with cutting tip **230** and other similar preferred cutting tip embodiments of this invention having hone bevels despite the fact that each hone bevel, as for example hone bevels **528-528-528** of cutting tip **230**, creates a wider angle than the corresponding proximal angle of the cutting tip in reference at a location closer to the corresponding cutting edge than the structure of the cutting tip that was used in reference to determine the angle of measure of the comparative proximal angle. Such a wider angle, or wider angles therefore could be determined as according to one measuring method by angular measuring reference points that are closer to corresponding cutting edges than the angular measuring reference points of the corresponding comparative proximal angle or proximal angles of the cutting tip and cutting edge in reference as has been defined in this specification.

FIGS. **57 & 58** illustrate a cutting tip **234** and a cutting tip **236**. Cutting tips **234 & 236** are identical to each other in certain structural features such as they each have facets **426-426-426**, bevels **530-530-530**, and bevel boundaries **626-626-626**. Cutting tips **234 & 236** however differ from each other in the location of their hone bevels and therefore the location of their cutting edges. Each hone bevel **532** of cutting tip **234** is located on the left side of its accompanying cutting edge **326** as seen when viewed from above in cross-section as depicted in FIG. **58**, whereas each hone bevel **534** of cutting tip **236** is located on the right side of its accompanying cutting edge **328** as seen when viewed from above in cross-section as depicted in FIG. **57**.

The bevel boundaries of the cutting tips as according to this invention generally define a location or boundary upon respective cutting tips where the structure of the cutting tip, particularly facets or area between cutting edges, change slope or change shape. Such change in slope or shape is generally best seen from cross-sectional views of the cutting tips but is also readily apparent from side views and top views of the respective cutting tips. It is apparent that the cutting tips as according to this invention having hone bevels or equivalents may also have hone bevel boundaries.

FIGS. **59 & 60** illustrate a cutting tip **232**. Cutting tip **232** has facets **424-424-424**, cutting edges **324-324-324**, bevels **522-522-522-522-522-522**, hone bevels **524-524-524-524-524-524** and bevel boundaries **624-624-624-624-624-624**. As is clearly evident from the enlarged view of one of the cutting edges **324** of cutting tip **232** as illustrated in FIG. **60**, each cutting edge **324** has two hone bevels **524-524** situated on opposite sides thereof.

FIGS. **61-64** illustrate a cutting tip **238**, yet another preferred embodiment as according to this invention. Cutting tip **238** has concave facets **430-430-430**, cutting edges **330-330-330**, flat planar bevels **536-536-536-536-536-536**, and bevel boundaries **630-630-630-630-630-630**. FIG. **64** illustrates that a proximal angle **686** has an angle of measure that is less than the angle of measure of a distal angle **688** as according to the proximal and distal angles of this invention and also that a proximal angle **682** has an angle of measure that is less than the angle of measure of a distal angle **684**. Angles **682 & 684** of FIG. **64** illustrate another example showing that the manner of determining the angle of measure of a particular structure or section of a cutting tip as according to this invention is not limited exclusively to angular measuring reference points and distances they are displaced from their corresponding cutting edges. For example, even though dotted lines **1020 & 1022** of angle **684** intersect adjoining facets **430-430** at facet bisecting planes **660-660** and do not

conjoin at a cutting edge **330** but rather at a point **1030** along one of the facet bisecting planes **660**, which coincidently bisects angle **684** into two substantially equal halves, they accurately represent an angle that adjoining facets **430-430** are offset from each other with respect to the shape of a section of cutting tip **238** that is distal or further from the cutting edge than the corresponding bevel boundaries **630-630**.

The term distal as used throughout this specification refers to being further away from whereas the term proximal refers to being closer to. Distal and proximal have been referenced from corresponding cutting edges with respect to proximal and distal angles, so therefore distal angles are determined from the angular offset of opposing cutting tip structures, such a facets and bevels, that are located a distance further from the cutting edge than opposing cutting tip structures that determine the angular offset of proximal angles, regardless of the cutting tip geometry, as has been discussed herein.

It is apparent that there exists a variety of angle measuring methods, some of which have been discussed herein, to determine that a particular section of a cutting tip, as according to this invention, which is located substantially closer to a corresponding cutting edge has a finer or narrower angle than a section of the same cutting tip located a distance substantially further from the same corresponding cutting edge, which generally but not limited to is determined as in a plane perpendicular to the central longitudinal axis of the respective cutting tip. Such cutting tips as according to the desired results of the cutting tips of this invention overcome deficiencies inherent in prior art cutting tips by providing a razor sharp cutting edge in combination with optimally desirable strong and durable facet structure.

FIG. **65** illustrates a cutting tip **240**. Cutting tip **240** has convex facets **432-432-432**, cutting

edges **332-332-332**, flat planar bevels **538-538-538-538-538-538**, and bevel boundaries **632-632-632-632-632-632**. Cutting tip **240** is similar to cutting tip **238** as illustrated in FIGS. **61-64**, except cutting tip **240** has convex or outwardly bulging facets, and therefore is a generally conical shaped cutting tip.

Although the cutting tips as according to this invention that are fabricated by machining - i.e. screw machines, grinding etc.- are preferably fabricated from round bar or rod stock, such as 12 foot lengths of stainless steel bar, it is apparent that a step in the manufacturing process to produce cutting tips as according to this invention could involve impact swaging of pellets or slugs to form at least part of the primary shape or structure of a cutting tip, wherein after the razor sharp cutting edges and/or bevels could be ground thereon after hardening was completed. Impact swaging could allow cutting tips, as according to some of the preferred embodiments of this invention which have facet structures that are complex and costly to machine such as the convex facets **432-432-432** of cutting tip **240**, to be economically and quickly produced.

It is apparent that flat bevels such as bevels **538** of cutting tip **240** as illustrated in FIG. **65** could be swaged or formed during impact swaging and that hone bevels or other bevels, such as curved bevels could then be ground or formed thereon to provide a sharper cutting edge as according to the desired results of this invention.

FIGS. **66-68** illustrate a cutting tip **242**. Cutting tip **242** differs from the other cutting tips of this invention that have been heretofore disclosed in that cutting tip **242** has attachable tip blades **350-350-350**, which each fit into a corresponding slot **910** of a metal tip body **1040** as is illustrated in FIG. **68**. Tip blades **350-350-350** each have a pair of bevels **540-540** and a cutting edge **334**. Each tip blade **350** abuts against a nipple **908** of tip body **1040** and against a pair of bevel boundaries

628-628 when attached thereto. Nipple **908** is preferably integral with tip body **1040**. Tip blades **350-350-350** are preferably welded integrally to tip body **1040**. It is apparent that tip blades **350-350-350** and other tip blades or their equivalents as according to this invention may be attached to tip bodies, whether of metal construction, polymer or of other materials or combinations thereof, by a variety of different methods including glueing, welding, molding, and by modifications in the shapes of the tip blades and/or tip bodies.

FIGS. **69-72** illustrate a cutting tip **244**. Cutting tip **244** differs from the other cutting tips of this invention that have been heretofore disclosed in that cutting tip **244** has three integral cutting edges **336-336-336** that each extend substantially the full length of cutting tip **244** from the junctures between the facets rearward along a barrel section **906**. A pair of bevel boundaries **634a-634a** defines the boundary of a corresponding pair of bevels **542-542** with corresponding facets, as is illustrated in FIG. **71**. Another pair of bevel boundaries **634b-634b** defines the boundary of a pair of corresponding bevels **544-544** with barrel section **906**, as is illustrated in FIG. **72**. Cutting edge **336** between each pair of adjoining facets is coplanar or in-line with the section of cutting edge **336** that extends rearward upon barrel section **906**.

FIGS. **73-76** illustrate a cutting tip **246**. Cutting tip **246** is similar to cutting tip **244** as illustrated in FIGS. **69-72** except for the three cutting edges **338-338-338** of cutting tip **246** are the razor edges of attachable tip blades **352-352-352**, which each fit into a corresponding slot **912** of a metal tip body **1042** as is illustrated in FIG. **76**. Tip blades **352-352-352** each have a pair of bevels **546-546** that are situated between adjacent facets and form bevel boundaries **636a-636a** thereat. Each tip blade **352** also has a pair of bevels **548-548** that run along barrel section **907** and form bevel boundaries **636b-636b** thereat.

FIGS. **77-81** illustrate cutting tips **248, 250, 252 & 254** which all in common have bevels on both sides of their facet junctures such that the bevels do not extend completely to the forward leading apex of their respective cutting tips. Cutting tip **248** as illustrated in FIGS. **77 & 78** has three facets **434-434-434**, a pair of bevels **550-550** that forms each cutting edge **340** and a three sided apex **917**. It is apparent that each side of apex **917** could be hollow ground and therefore substantially concave. Each facet has a curved section **552** between bevels **550-550** thereon. It is apparent that the facets of cutting tip **248** could be cut or formed at least in part from a rotational machining tool whose axis of rotation changes in spatial orientation relative to the X-Y-Z axises of cutting tip **248** while forming a complete cut or at least a portion thereof. Cutting tip **248** has a barrel section **914** that is necked down as illustrated in FIG. **77**. Cutting tip **250** as illustrated in FIG. **79** has four facets each with a cutting edge **342** that extends from between facet junctures rewards upon barrel section **914** thereof. Cutting tip **252** as illustrated in FIG. **80** is similar to cutting tip **250** except the four cutting edges **344-344-344-344** of cutting tip **252** are found only along the junctures between the respective facets. Cutting tip **254** as illustrated in FIG. **81** has a substantially blunt apex **916**, and four flat planar facets each with a cutting edge **346** that is found only along the junctures between the respective facets.

It is apparent that the cutting tips of this invention may have cutting edges as according to this invention along any axial length of their structure, whether integrally formed with, integrally attached or removably attachable to their respective cutting tips. It is also apparent that the cutting edges of a cutting tip as according to this invention may be aligned or oriented with respect to the central longitudinal axis thereof, the three dimensions as depicted in this specification by a Cartesian X-Y-Z axis system wherein the Y-axis is collinear with the central longitudinal axis thereof, and the

facet junctures of their respective cutting tip in a variety of different manners. Such different aligned or oriented manners of the cutting edges include being inclined relative to one or more of the X, Y or Z axises and not being coplanar with a corresponding facet juncture. It is also apparent that cutting edges as according to this invention that are situated upon the barrel sections or equivalents of their respective cutting tips may be aligned or oriented with respect to the facet junctures of their cutting tips in a variety of manners, including not being in-line or coplanar with them.

FIGS. **82-84** illustrate a cutting tip **256**. Cutting tip **256** has attachable tip blades **354-354-354** each having a cutting edge **348** and a pair of bevels **554-554**. Each tip blade **354** fits into a slot **920** in the barrel section **918** of tip body **1044** where a pair of bevel boundaries **640-640** contact each tip blade **354**. Tip body **1044** is preferably of a metal construction and tip blades **354-354-354** are preferably non-removably attached to tip body **1044** by welding, such as capillary welding or other welding techniques, but not limited thereto.

FIG. **85** illustrates a blade-opening arrowhead **758** with cutting tip **256** attached at the leading penetrating end.

FIGS. **86 & 87** illustrate a cutting tip **258** similar to cutting tip **256**, but which is integrally attached with an arrowhead body **734** of a blade-opening arrowhead **760**.

FIG. **88** illustrates a cross-section of a cutting tip **259** which is similar to cutting tip **258** of blade-opening arrowhead **734**, except the tip blades are integrally fabricated with cutting tip **259**.

Securement means as according to this invention has the intended meaning that a removably attachable tip blade or equivalent is retained in a cutting position when assembled with or to a corresponding tip body such that a plane perpendicular to the central longitudinal axis of the cutting tip intersects both a holding element, and a portion of the tip blade that is situated closer to the

central longitudinal axis of the cutting tip than the holding element. Holding elements as according to this invention comprise portions of tip bodies, arrowhead bodies or mandrels, arrowhead blades, or other suitable structure or structures of the penetrating device utilizing such a cutting tip as according to this invention, or any combination of such structures that serve to limit undesired displacement or movement of tip blades. In this manner the tip blades will engage against the holding element or elements and therefore resist displacement in a radial direction as well as in axial directions from the tip body, thus securing the tip blades to their respective cutting tips.

FIGS. **89** & **90** illustrate an example of securement means as according to this invention where a cutting tip **260** is shown to be removably attachable to a blade-opening arrowhead body. Cutting tip **260** has three facets, three slots **928-928-928** each with a catch-lip **926**, three removably attachable tip blades **356-356-356** (only two tip blades **356-356** are shown for reasons of simplicity and illustration), and a tip body **1046** having an internally threaded female cavity **930** that threads onto a threaded male stud **762** of the arrowhead body. Each tip blade **356** has a notch **932** and a protrusion **933**. Therefore, when tip blades **356-356-356** are inserted into slots **928-928-928** and tip body **1046** is threaded onto stud **762** each notch **932** mates with each corresponding catch-lip **926** such that each protrusion **933** is positioned forward of the rearward terminus of its corresponding catch-lip **926** thereby securing each tip blade **356** to tip body **1046** as according to the securement means of this invention. As is clearly illustrated in FIG. **90** a plane **1028** which is perpendicular to the central longitudinal axis of cutting tip **260** intersects protrusion **933** of each tip blade at a location closer to the central longitudinal axis of cutting tip **260** than the locations plane **1028** intersects each corresponding catch-lip **926** of tip body **1046**, as is according to the securement means of this invention. Catch-lips **926-926-926** are examples of holding elements as according to the securement

means of this invention.

FIG. **91** illustrates a tip blade **360** which is similar to tip blade **356** except tip blade **360** has a sloped rear edge **934** which will minimize any possible barbing effect that could occur when a corresponding cutting tip is retracted from the substance it had penetrated.

FIGS. **92 & 93** illustrate another example of securement means as according to this invention where a cutting tip **264** is shown to be removably attachable to a blade-opening arrowhead body. Cutting tip **264** has three facets, three slots **928-928-928** each with a catch-lip **926**, three removably attachable tip blades **362-362-362**, and a tip body **1046** having an internally threaded female cavity **930** that threads onto a threaded male stud **782** of the arrowhead body. Stud **782** has a depression **764** centrally axially formed at its forward end, as is illustrated in FIG. **92**. Each tip blade **362** has a prong **940** and an arm **938**. Prongs **940-940-940** are similar to protrusion **933-933-933** except that each prong **940** extends in a rearward direction when tip blades **362-362-362** are secured to cutting tip **264**, whereas each protrusion **933** extends in a forward direction when tip blades **356-356-356** are secured to cutting tip **260**. Therefore, when tip blades **362-362-362** are inserted into slots **928-928-928** and tip body **1046** is threaded onto stud **782** each prong **940** mates within depression **764** such that each prong **940** is positioned rearward of the forward terminus of stud **782** thereby securing each tip blade **362** to tip body **1046** as according to the securement means of this invention. As is clearly illustrated in FIG. **93** plane **1028** which is perpendicular to the central longitudinal axis of cutting tip **264** intersects each prong **940** of each tip blade at a location closer to the central longitudinal axis of cutting tip **264** than the locations plane **1028** intersects stud **782** of tip body **1046**, as is according to the securement means of this invention. It is apparent that tip blades **362-362-362** could also each have a protrusion **933** and a notch **932** so as to mate with catch-lips **926** to

further aid in the securement of tip blades to tip body **1046**, as according to the desired results of this invention.

FIGS. **94-96** illustrate another example of securement means as according to this invention where a cutting tip **266** is shown to be removably attachable to a blade-opening arrowhead body. Cutting tip **266** has three facets, three slots **986-986-986** each with a catch-lip **926**, three removably attachable tip blades **364-364-364**, and a tip body **1048** having an internally threaded female cavity **944** that threads onto a threaded male stud **784** of the arrowhead body. Internal cavity **944** has a larger diameter flange cavity **946** situated rearward of the threaded internal section as is illustrated in FIG. **94**. Each tip blade **364** has a flange **942** as is illustrated in FIG. **96**. Each flange **942** is substantially not coplanar with at least another section of its corresponding tip blade **364** as is clearly illustrated in FIG. **96**. Therefore, when tip blades **364-364-364** are inserted into slots **986-986-986** and tip body **1048** is threaded onto stud **784** each flange **942** mates within flange cavity **946** such that each flange **942** is positioned circumferentially or laterally away from the opening of its corresponding slot **986** and against the inside wall of flange cavity **946** thereby securing each tip blade **364** to tip body **1048** as according to the securement means of this invention. As is clearly illustrated in FIG. **95** a plane **1028** which is perpendicular to the central longitudinal axis of cutting tip **266** intersects each flange **942** of each tip blade at a location closer to the central longitudinal axis of cutting tip **266** than the locations plane **1028** intersects tip body **1048**, as is according to the securement means of this invention.

As is illustrated in FIGS. **97a-c** it is apparent that tip blades having flanges **942** in combination with other tip blade structures as disclosed herein will further aid in the securement of the tips blades to corresponding tip bodies, as according to the securement means of this invention.

FIGS. **98 & 99** illustrate another example of securement means as according to this invention where a cutting tip **268** is shown to be removably attachable to a blade-opening arrowhead body. Cutting tip **268** has three facets, three slots **986-986-986** each with a catch-lip **926**, three removably attachable tip blades (of which one is a tip blade **366** and another is a tip blade **368)** as is illustrated in FIG. **98**, and a tip body **1048** having an internally threaded female cavity that threads onto stud **784** of the arrowhead body. For reasons of simplicity FIGS. **98 & 99** show only two tip blades **366** and **368**, but it is apparent that cutting tip **268** utilizes three tip blades. The arrowhead body has an annular recess **768** situated about stud **784**. Tip blade **366** has a leg **952** and tip blade **368** has a leg **954**. Leg **954** of tip blade **368** is an extension of flange **942**. Therefore, when both blades **366 & 368** are inserted into their slots **986-986** and tip body **1048** is threaded onto stud **784** leg **954** of tip blade **368** and leg **952** of tip blade **366** mate within annular recess **768** such that each leg is positioned rearward of the forward terminus of annular recess **768** thereby securing each tip blade **366 & 368** to tip body **1048** as according to the securement means of this invention. As is clearly illustrated in FIG. **99** plane **1028** which is perpendicular to the central longitudinal axis of cutting tip **268** intersects leg **954** of tip blade **368** and leg **952** of tip blade **366** at locations closer to the central longitudinal axis of cutting tip **268** than the locations plane **1028** intersects the arrowhead body, as is according to the securement means of this invention. As is obvious from FIG. **99** tip blades **366 & 368** may also incorporate other structural tip blade variations of the securement means according to this invention as have been disclosed herein, in combination with legs **952 & 954** or their equivalents which mate in annular recesses like annular recess **768**.

FIGS. **100 & 101** illustrate yet another example of securement means as according to this invention where a cutting tip **270** is shown to be removably attachable to a blade-opening arrowhead

body. Cutting tip **270** has three facets, three slots **960-960-960**, three removably attachable tip blades **370-370-370**, and a tip body **1050**. Tip body **1050** has an undercut cavity **958**, a sloped undercut wall **970**, an externally threaded male stud **962** that threads into a threaded female cavity **968** of the arrowhead body. Sloped undercut wall **970** abuts against an annular shelf **966** of the arrowhead body when tip body **1050** is attached thereto. The arrowhead body has a larger diameter leg cavity **984** situated forward of threaded internal cavity **968** as is illustrated in FIG. **100**. Each tip blade **370** has an abutment edge **972** which abuts against annular shelf **966** of the arrowhead body as is illustrated in FIG. **101**. Each tip blade **370** has a leg **956** so that when tip blades **370-370-370** are inserted into slots **960-960-960** and tip body **1050** is threaded into cavity **968** each leg **956** mates within leg cavity **984** such that at least a portion of each leg **956** is positioned rearward of the forward terminus of the arrowhead body and against the inside wall of leg cavity **984** thereby securing each tip blade **370** to tip body **1050** as according to the securement means of this invention. As is clearly illustrated in FIG. **101** plane **1028** which is perpendicular to the central longitudinal axis of cutting tip **270** intersects each leg **956** of each tip blade **370** at a location closer to the central longitudinal axis of cutting tip **270** than the locations plane **1028** intersects the arrowhead body, as according to the securement means of this invention.

FIG. **102** illustrates a tip blade **372** having a notch **927** and a protrusion **935**. Tip blade **372** shows that catch-lip, notch and protrusion type securing features can be combined with legs **956** or their equivalents of the tip blades of this invention similar to a tip blade **370** so as to enhance the securement of the tip blades to their tip bodies.

FIGS. **103-106** illustrate how an example of securement means similar to the securement means embodiment as illustrated in FIGS. **100-101** as according to this invention is applicable to a

fixed-blade arrowhead. FIG. **105** shows that a cutting tip **271** is removably attachable to a fixed-blade arrowhead body. Each forward edge section **774** of the fixed cutting blades of the arrowhead abut against corresponding abutment edges **972-972-972** of tip blades **372-372-372** when the arrowhead is assembled as is illustrated in FIG. **104**. Tip body **1051** differs from tip body **1050** of cutting tip **270** as illustrated in FIGS. **100 & 101** in that tip body **1051** has a void **929** and a catch-lip **937** in each slot **966** thereof. Each tip blade **372** has a protrusion **935** and a notch **927**. Therefore, when tip blades **372-372-372** are inserted into slots **966-966-966** and tip body **1051** is threaded into the arrowhead body, each notch **927** mates with each corresponding catch-lip **937** such that each protrusion **935** is positioned forward of the rearward terminus of its corresponding catch-lip **937** thereby securing each tip blade **372** to tip body **1051** as according to the securement means of this invention. As is clearly illustrated in FIG. **104** plane **1028** which is perpendicular to the central longitudinal axis of cutting tip **271** intersects protrusion **935** of each tip blade at a location closer to the central longitudinal axis of cutting tip **271** than the locations plane **1028** intersects each corresponding catch-lip **937** of tip body **1051**, as is according to the securement means of this invention.

It is apparent that the securement means as according to this invention may be used to secure tip blades or their equivalents between facet junctures of cutting tips as according to this invention.

FIG. **107** illustrates a forward end **772** of a fixed-blade arrowhead blade **726**. It is apparent that the forward end of the fixed-blade arrowhead blades used in conjunction with cutting tips of this invention having tip blades, may have different shapes such as being substantially flat, so as to optimally fit with their corresponding cutting tip.

FIGS. **108 & 109** illustrate a cutting tip **272** of a fixed-blade arrowhead, which has fixed-

blade arrowhead cutting blades **728-728-728**. Each cutting blade **728** has a substantially straight cutting edge **982** at its forward end that abuts against an abutment edge **976** of a tip blade **376** which is secured to a female screw on type tip body **1052** as according to the securement means of this invention. Cutting tip **272** as illustrated in FIG. **109** provides razor sharp tip blades or cutting blades on a chisel type cutting tip while also allowing to lock the upper section **982** of a fixed cutting blade **728** to an arrowhead body by tucking the forward end of the arrowhead blade in an undercut cavity of the chisel type tip - as is a very common practice in the archery industry.

FIG. **111** shows a press-on fit tip **274** which has tip blades **378-378-378**, an undercut wall **980** that abuts against an annular shelf **780** of the arrowhead body, and an internal female cavity **978** which fits around a male stud **778** of the arrowhead body when tip **274** is pressed thereon.

It is apparent that there are many methods of attaching the cutting tips as according to this invention to their respective penetrating devices, including forming them integrally thereon.

FIGS. **112 & 113** illustrated a press-on fit cutting tip **276**. Cutting tip **276** is similar to cutting tip **274** as illustrated in FIG. **111** except cutting tip **276** has cutting edges **330-330-330** and accompanying bevels as according to this invention located at the facet junctures in addition to having tip blades **378-378-378** on the barrel section thereof.

It is apparent that the cutting tips as according to this invention may have both true cutting edges or razor sharp cutting edges as according to this invention at their facet junctures or equivalents as well as on their barrel sections or equivalents, which may comprise tip blades as have been disclosed herein. It is apparent that any of the different facet juncture cutting edge designs as illustrated or suggested herein may be combined with any of the tip blade designs, including in manners that have not been suggested herein.

It is apparent that different cutting tips as according to the desired results of this invention exist which have not been discussed above. It is apparent that the different parts and structural shapes and their equivalents as according to the cutting tips of this invention, as discussed above and as according to other preferred embodiments of this invention, can be changed, or interchanged, or eliminated, or duplicated, or made of different materials, and connected to or associated with adjacent elements in different manners, other than suggested herein, without deterring from the desired results of the cutting tips as according to this invention.

For example FIGS. **114 & 115** show a cutting tip **278** that has both integral cutting edges **316-316-316** each formed by a pair of bevels **516-516** at facet junctures, in conjunction with cutting edges **376-376-376** of tip blades **378-378-378** on the barrel section thereof.

Also FIGS. **116 & 117** illustrate a cutting tip **280** that has both integral cutting edges **300-300-300** each formed by a corresponding bevel **500** at facet junctures, and cutting edges **376-376-376** of tip blades **378-378-378** on the barrel section thereof. It is apparent that cutting edges **376-376-376** could be integrally formed with the barrel section of cutting tip **280** or that they could be attachable whether removably so or not. It is apparent that each cutting edge **376** may be an integrally ground part of the barrel section of cutting tip **280**.

FIGS. **118-131** illustrate cross-sectional views of cutting tips **282-294** as according to this invention. Cutting tips **282-294** illustrate other possible structural arrangements of facet sections and/or barrel sections that may be associated with or be part of the cutting tips as according to this invention. It is apparent that cutting edges of cutting tips **282-294** could be integrally formed or ground thereon or that they could be attachable whether removably so or not, despite how they are specifically illustrated in FIGS. **118-131**.

It is apparent that the number of cutting edges per individual cutting tip i.e. attachable tip blades and/or integrally formed cutting edges such as formed at facet junctures by one or more bevels, may vary. The number of cutting edges is preferably between 1 and 7 but may include more depending on the tip design and intended use of the penetrating or cutting device. Although the preferred embodiments of this invention have predominantly illustrated a ratio of one cutting edge for each facet of a corresponding cutting tip, it is apparent that cutting tips having more than one cutting edge per facet is within the scope of this invention, especially in cutting edge arrangements other than have been disclosed herein.

It is to be understood that the present invention is not limited to the sole embodiments described above, as will become apparent to those skilled in the art, but encompasses the essence of all embodiments, and their legal equivalents, within the scope of the following claims.